Alex Blanchard
UNF
On Demand Manufacturing of Mutlimaterials PI

PORTLAND HIGH SCHOOL 1821 2021 200 YEARS

UNIVERSITY OF SOUTHERN MAINE

FLORIDA STATE UNIVERSITY 1851

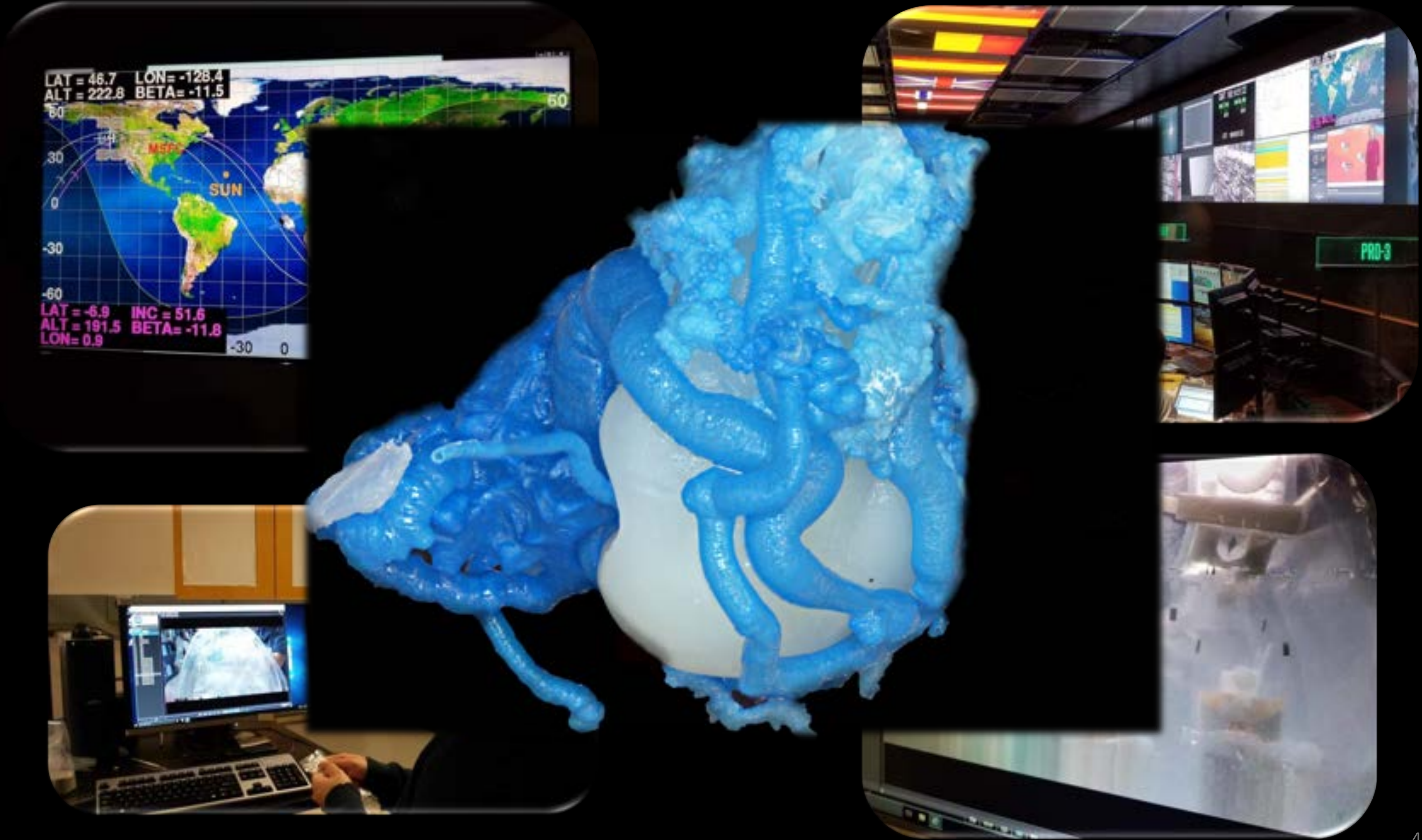
2004	2006	2010	2011	2012	2017	2020

SOUTHERN MAINE COMMUNITY COLLEGE envision a future

Maine Medical Center Research Institute

A MaineHealth Member

NASA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LAT = -6.9 INC = 51.6
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LON= 0.9
PRD-3

NASA: An Early History

- NASA was created in response to the Soviet launching of Sputnik in 1957
- John F. Kennedy proposed that the United States put a man on the moon by the end of the 1960's, thus began the Apollo program
- In 1969 Neil Armstrong was the first person to set foot on the Moon
- Apollo missions 11, 12, 14, 15, 16, and 17 all successfully landed people on the Moon
- Eugene Cernan was the last person to walk the moon on December 6, 1972

Photo Credit: NASA

Redstone Arsenal

- Redstone Arsenal is a U.S. Army post located in Huntsville, Alabama.
- It was established in 1941 as a chemical weapons manufacturing facility and was originally known as the Huntsville Arsenal.
- During World War II, Redstone Arsenal was used for the production of various chemical weapons, including mustard gas and tear gas.
- After the war, the arsenal was repurposed for missile research and development and was renamed Redstone Arsenal in 1949.

Credit: Wiki Commons

Operation Paperclip

Operation Paperclip was a secret U.S. government program after WWII.

German scientists and engineers were brought to the U.S. as part of the program.

These scientists played a key role in the U.S. space program and other technological advancements.

The German scientists played a key role in the U.S. space program, including the Apollo missions to the moon.

Wernher von Braun

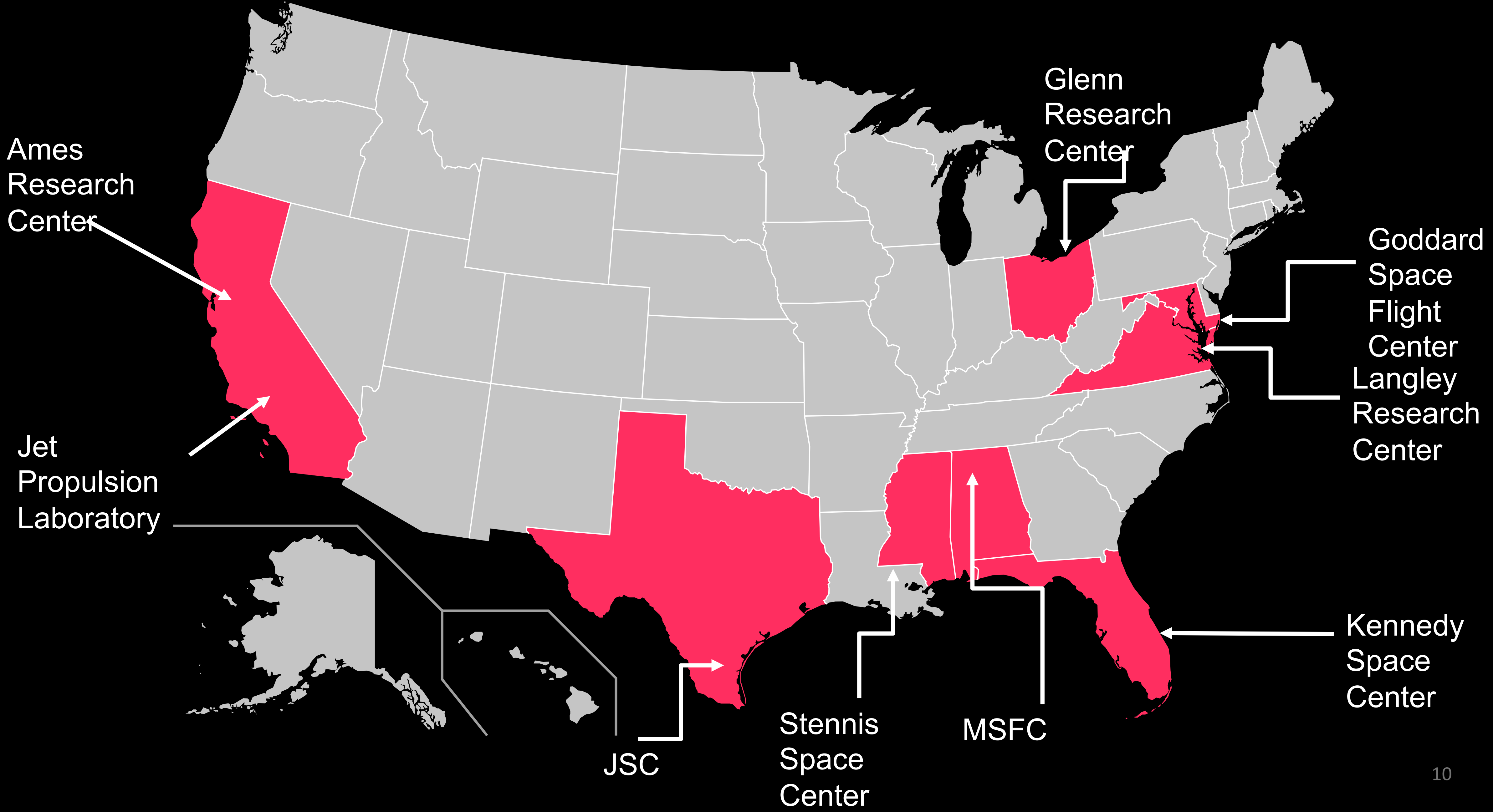
- Born in 1912 in Wirsitz, Germany
- Studied physics and mathematics at the Berlin Institute of Technology
- Worked for the German Army as a rocket engineer during World War II
- Led the team responsible for developing the V-2 rocket, which was used against England
- Surrendered to American forces at the end of the war and was brought to the United States as part of Operation Paperclip

Wernher von Braun

Worked for the U.S. Army at the Redstone Arsenal in Alabama, where he played a key role in the development of the Redstone rocket

Became a naturalized citizen of the United States in 1955

Joined the National Aeronautics and Space Administration (NASA) in 1960, where he served as the head of the Marshall Space Flight Center and played a key role in the development of the Saturn V rocket used in the Apollo program.


Ames Research Center
Jet Propulsion Laboratory
JSC
Stennis Space Center
MSFC
Kennedy Space Center
Glenn Research Center
Goddard Space Flight Center
Langley Research Center

OCCUPATIONAL OUTLOOK HANDBOOK

Search Handbook Go

Materials Engineers

PRINTER-FRIENDLY

Summary

Quick Facts: Materials Engineers	
2021 Median Pay	$98,300 per year $47.26 per hour
Typical Entry-Level Education	Bachelor's degree
Work Experience in a Related Occupation	None
On-the-job Training	None
Number of Jobs, 2020	25,100
Job Outlook, 2020-30	8% (As fast as average)
Employment Change, 2020-30	2,100

What Materials Engineers Do

Materials engineers develop, process, and test materials used to create a wide range of products.

Work Environment

Materials engineers generally work in offices where they have access to computers and design equipment. Others work in factories or research and development laboratories. Materials engineers typically work full time and may work overtime hours when necessary.

How to Become a Materials Engineer

Materials engineers typically need a bachelor's degree in materials science and engineering or in a related engineering field. Completing internships and cooperative-engineering programs while in school may be helpful for gaining hands-on experience.

A major malfunction

Challenger's brief flight

.678 seconds

Following Challenger's liftoff, a puff of black smoke — seen only by automatic launch cameras — indicates a problem with one of the O-ring seals at the joint between segments of the shuttle's right-hand solid rocket booster.

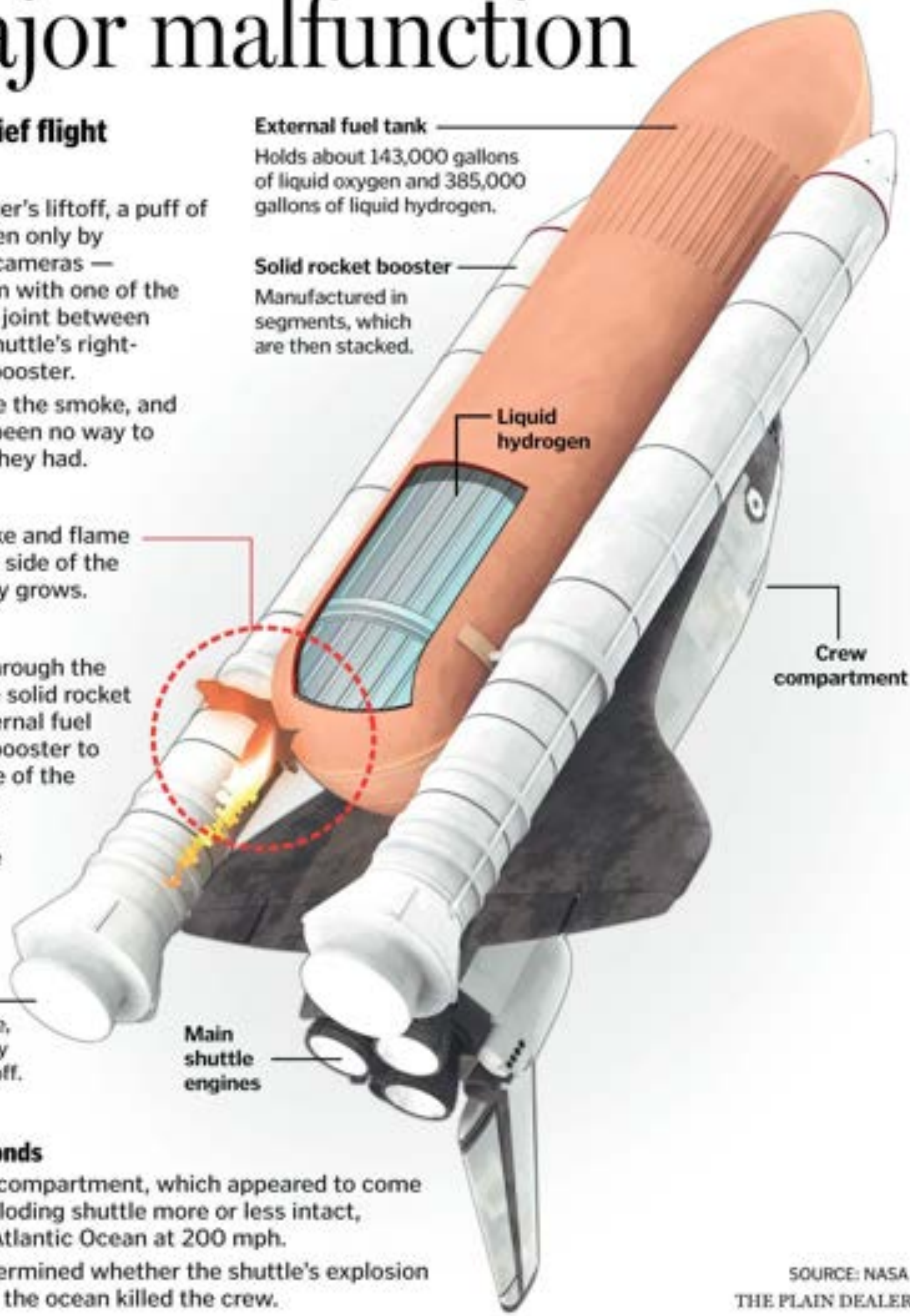
No human eyes see the smoke, and there would have been no way to abort the flight if they had.

58 seconds

A small jet of smoke and flame bursts through the side of the booster and quickly grows.

73 seconds

The flame burns through the strut attaching the solid rocket booster to the external fuel tank, causing the booster to swivel into the side of the tank. The resulting massive explosion destroys the space shuttle.



3 minutes, 58 seconds

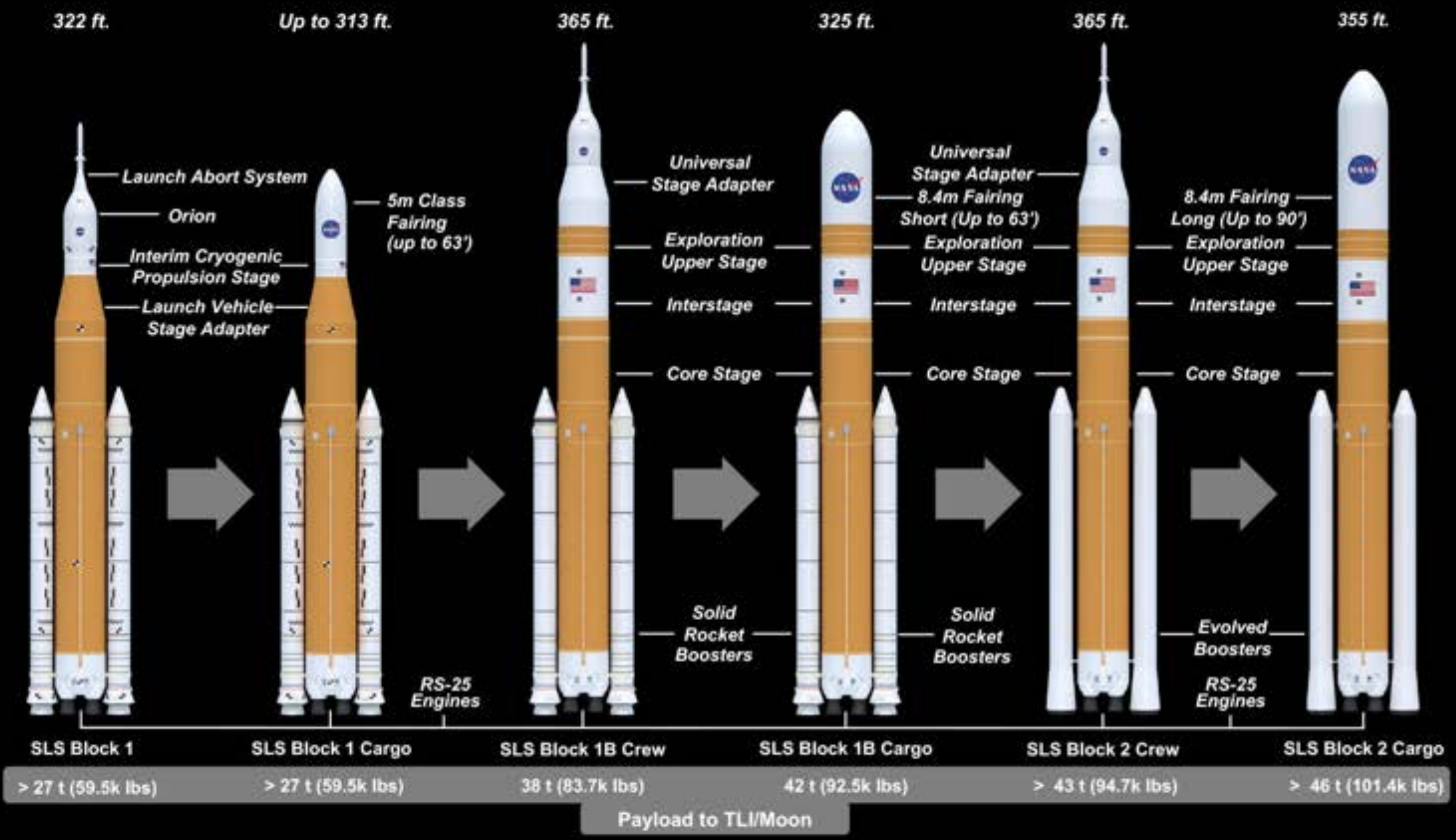
Challenger's crew compartment, which appeared to come away from the exploding shuttle more or less intact, smashes into the Atlantic Ocean at 200 mph.

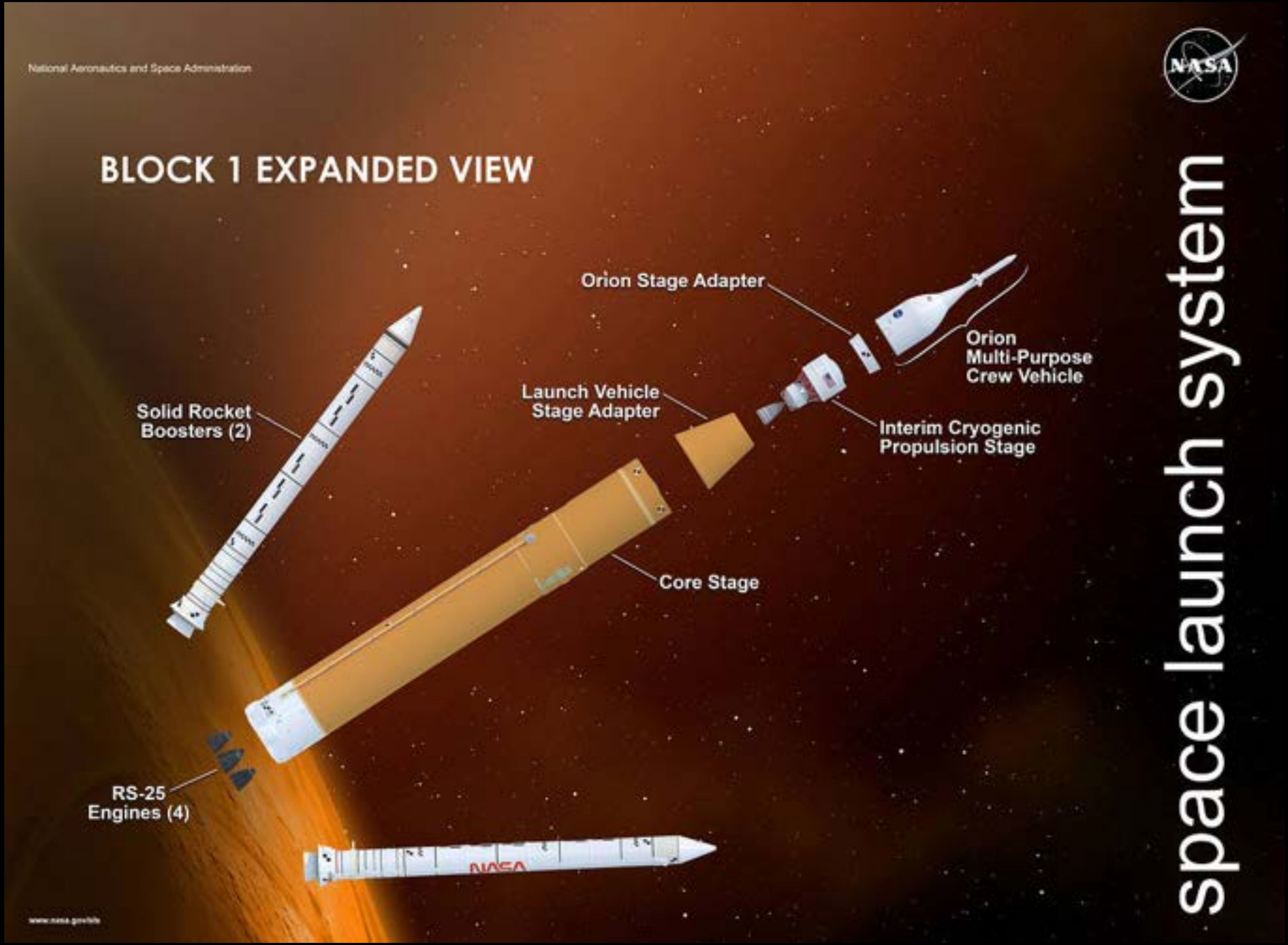
Officials never determined whether the shuttle's explosion or the impact with the ocean killed the crew.

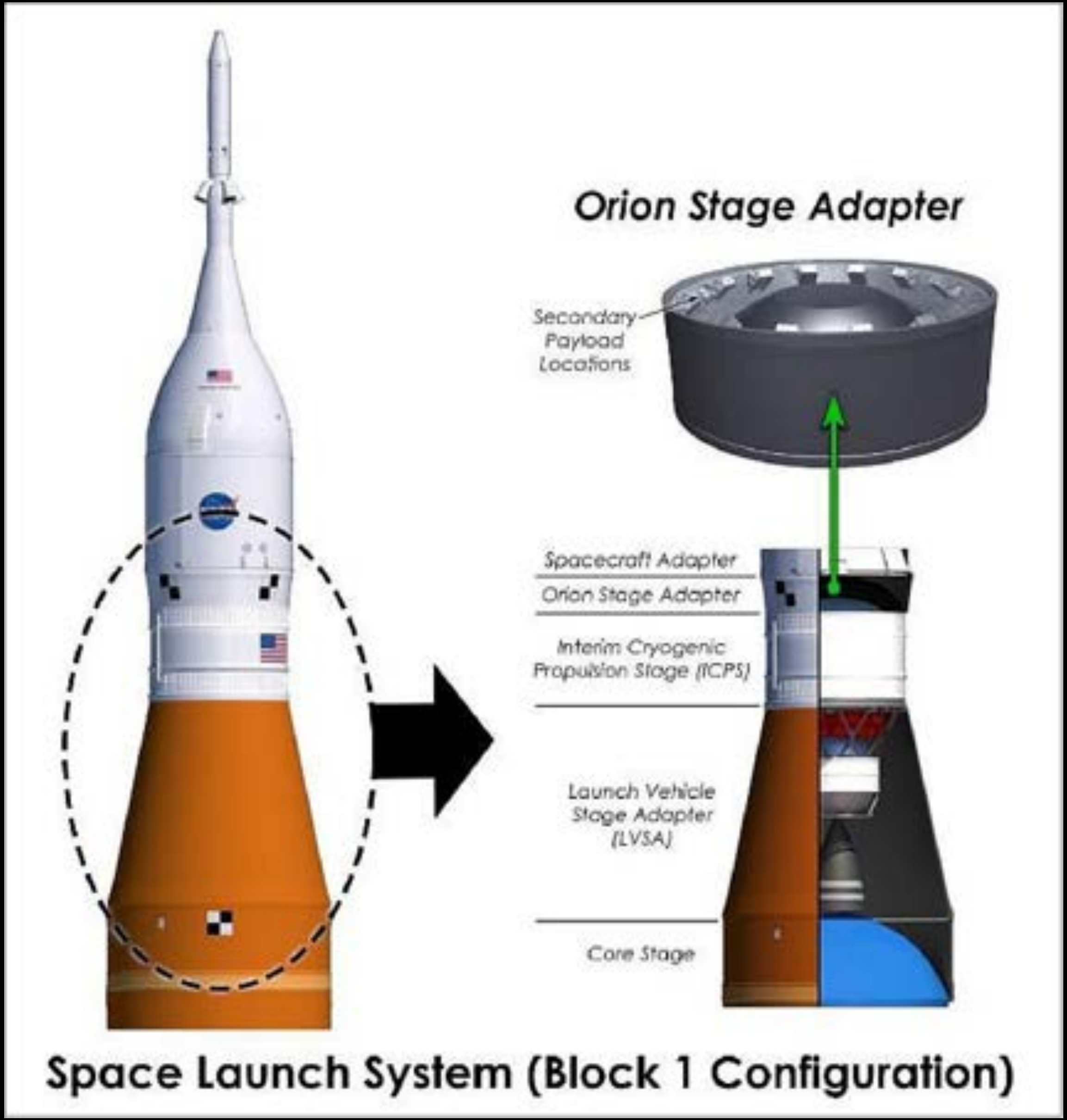
SOURCE: NASA
THE PLAIN DEALER

SLS EVOLVABILITY

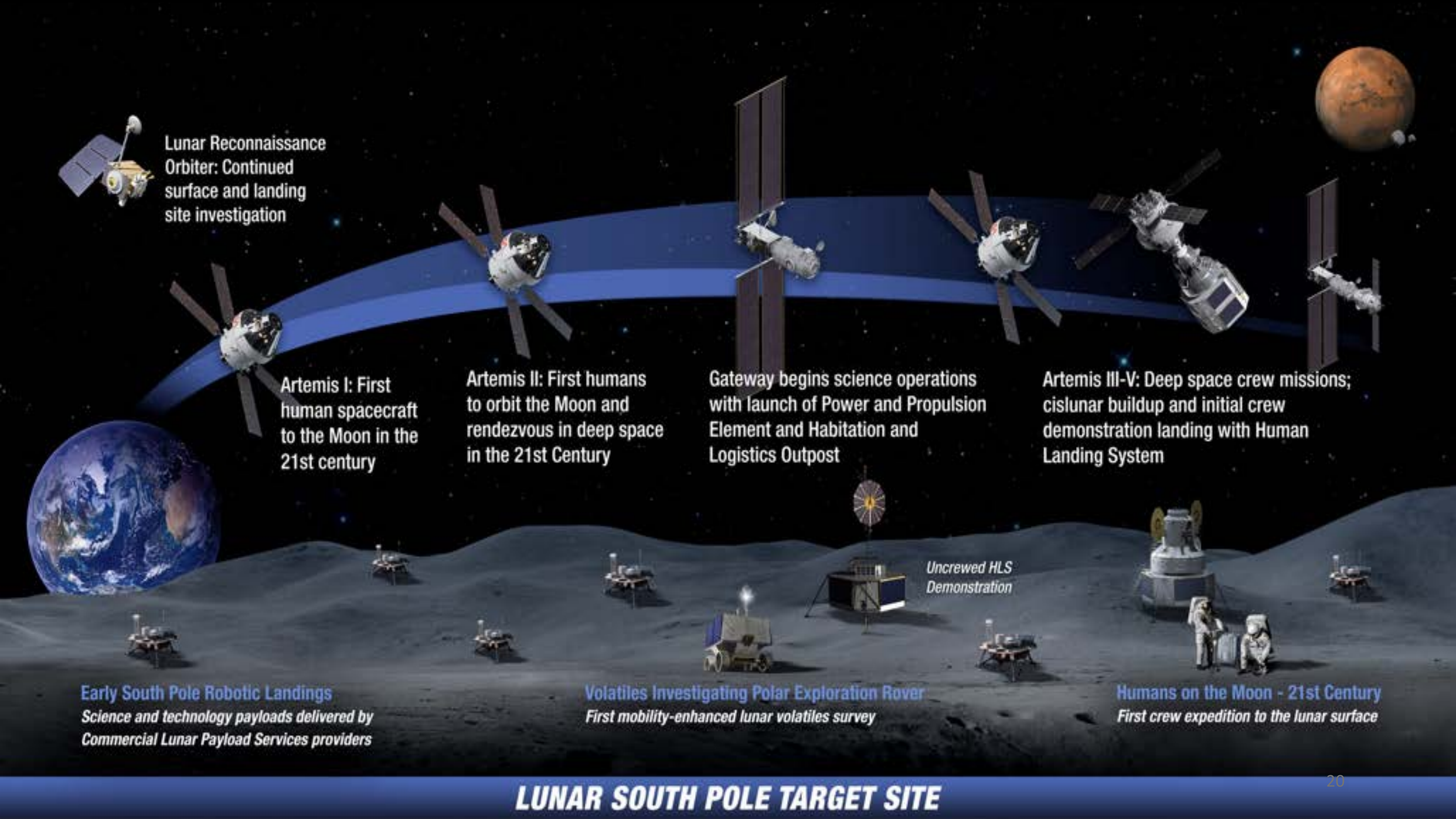
FOUNDATION FOR A GENERATION OF DEEP SPACE EXPLORATION



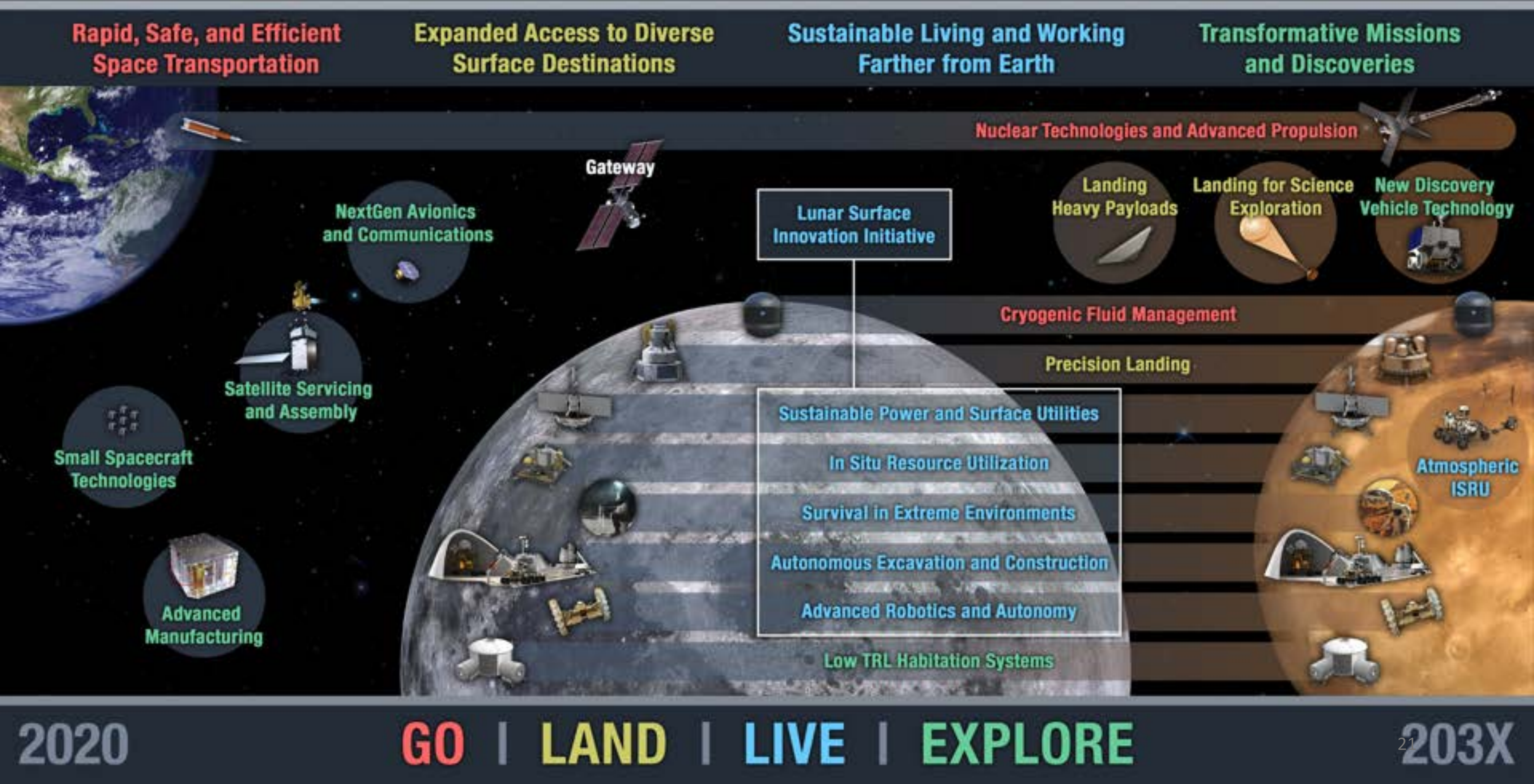

National Aeronautics and Space Administration
BLOCK 1 EXPANDED VIEW
Orion Stage Adapter
Orion Multi-Purpose Crew Vehicle
Launch Vehicle Stage Adapter
Interim Cryogenic Propulsion Stage
Solid Rocket Boosters (2)
Core Stage
RS-25 Engines (4)
NASA
space launch system


Orion Stage Adapter
Secondary Payload Locations
Spacecraft Adapter
Orion Stage Adapter
Interim Cryogenic Propulsion Stage (ICPS)
Launch Vehicle Stage Adapter (LVSA)
Core Stage
Space Launch System (Block 1 Configuration)

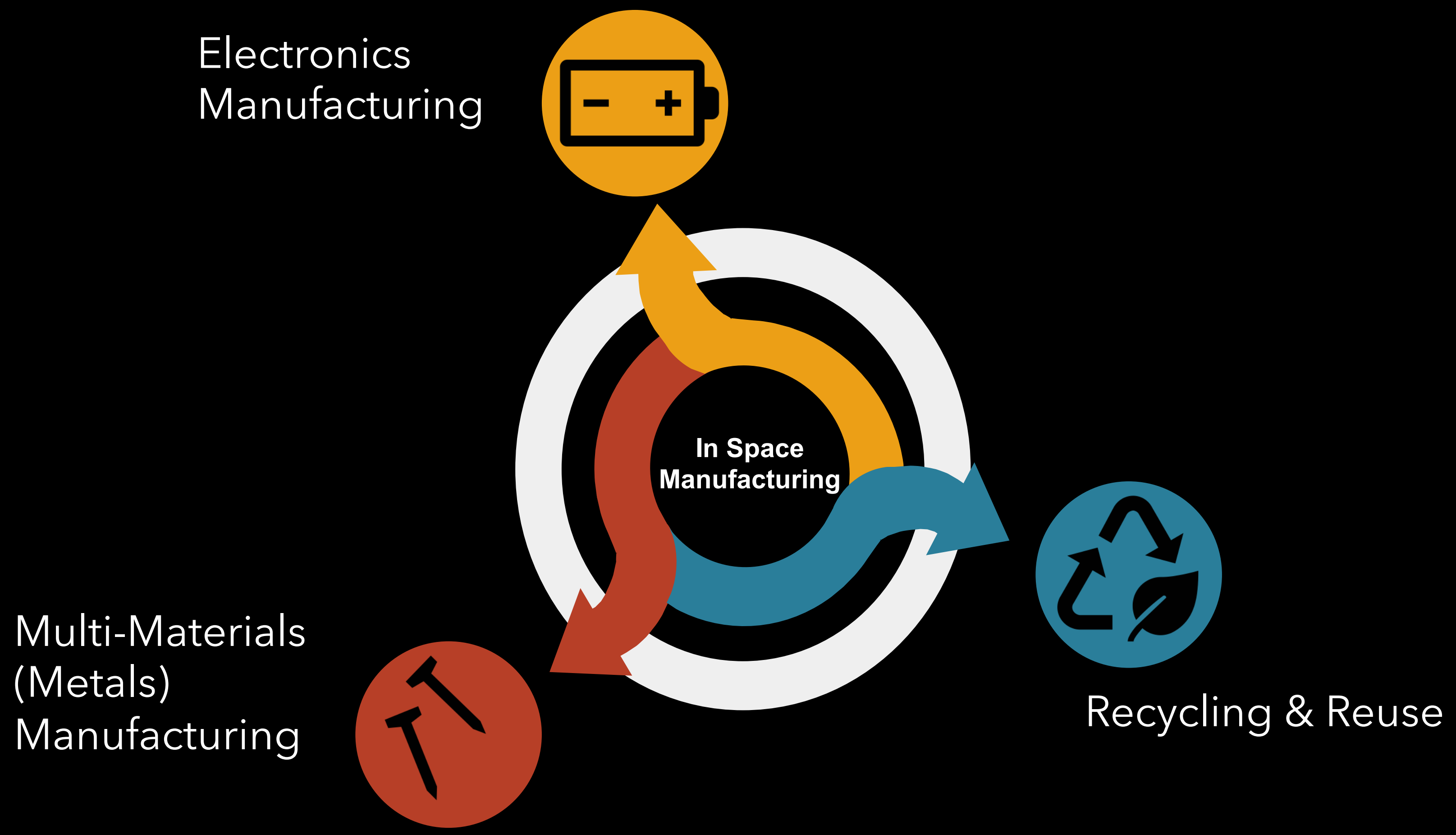

WIDE LOAD


Lunar Reconnaissance Orbiter: Continued surface and landing site investigation
Artemis I: First human spacecraft to the Moon in the 21st century
Artemis II: First humans to orbit the Moon and rendezvous in deep space in the 21st Century
Gateway begins science operations with launch of Power and Propulsion Element and Habitation and Logistics Outpost
Artemis III-V: Deep space crew missions; cislunar buildup and initial crew demonstration landing with Human Landing System
Uncrewed HLS Demonstration
Early South Pole Robotic Landings
Science and technology payloads delivered by Commercial Lunar Payload Services providers
Volatiles Investigating Polar Exploration Rover
First mobility-enhanced lunar volatiles survey
Humans on the Moon - 21st Century
First crew expedition to the lunar surface
LUNAR SOUTH POLE TARGET SITE

TECHNOLOGY DRIVES EXPLORATION




Athletic Shoes
Nike Air trainers wouldn't exist if it wer
suit construction technology develo
NASA. It was a former NASA
first pit
Systems
ASA's surplus rocket
t can safely destroy
ning a hole through
Home Insulation
Space is a place of extreme temperatures, knowing this NASA developed insulation from aluminised polyester called Radiant Barrier, used today in most home insulations.
NASA and Diate
aural thermo
astronomy technol
of ene
CAT scanners and radiography.
reless Headsets
NASA, being one of the forerunners for advancing communication technology, developed these headsets to allow astronauts to be hands-free without wires.


Electronics
Manufacturing
In Space
Manufacturing
Multi-Materials
(Metals)
Manufacturing
Recycling & Reuse

➡

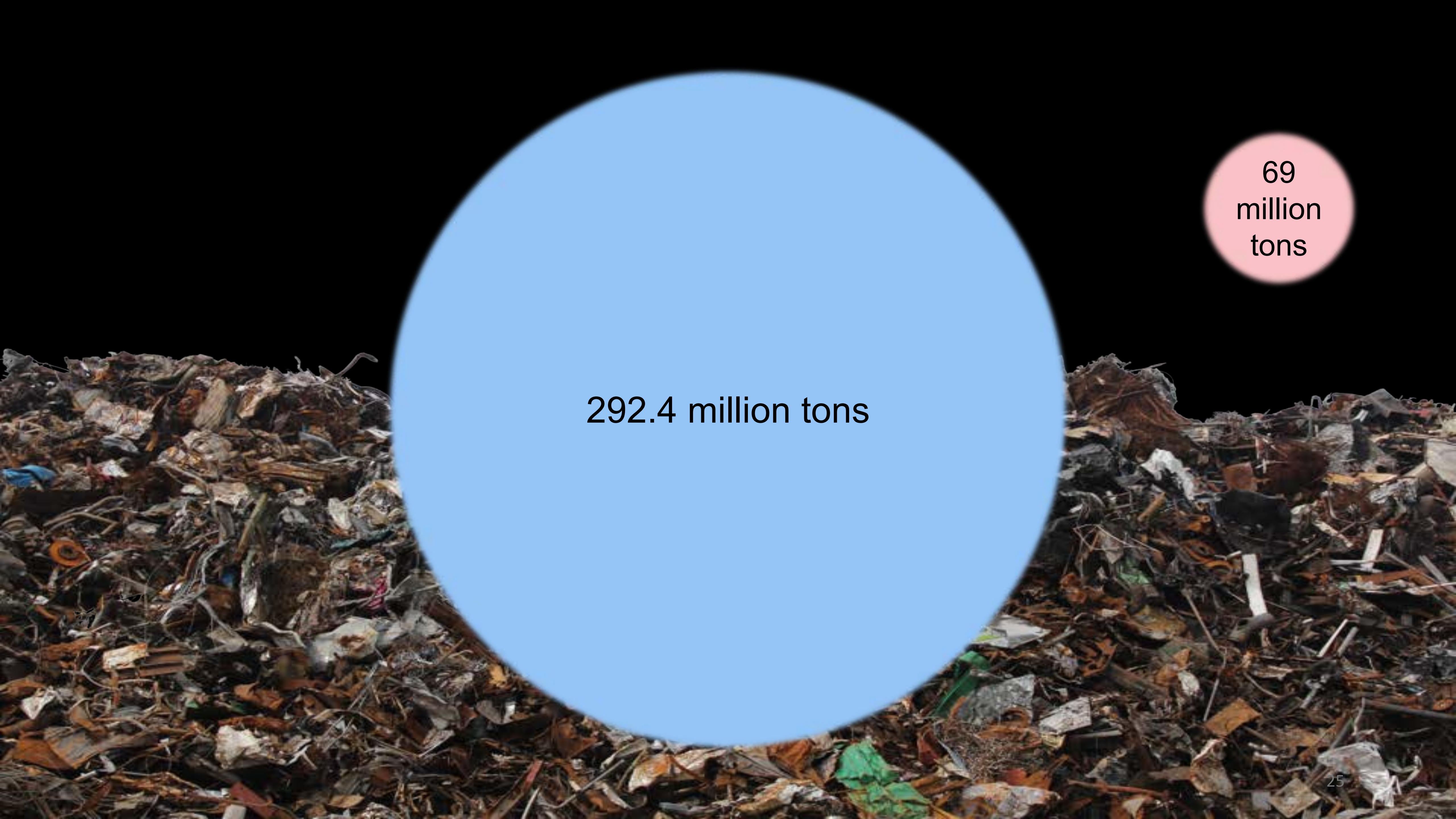
➡

ISS - Demonstrate

Gateway – Use (Small Scale)

Habitat – Use (Large Scale)

Photo Credits: NASA


69
million
tons
292.4 million tons

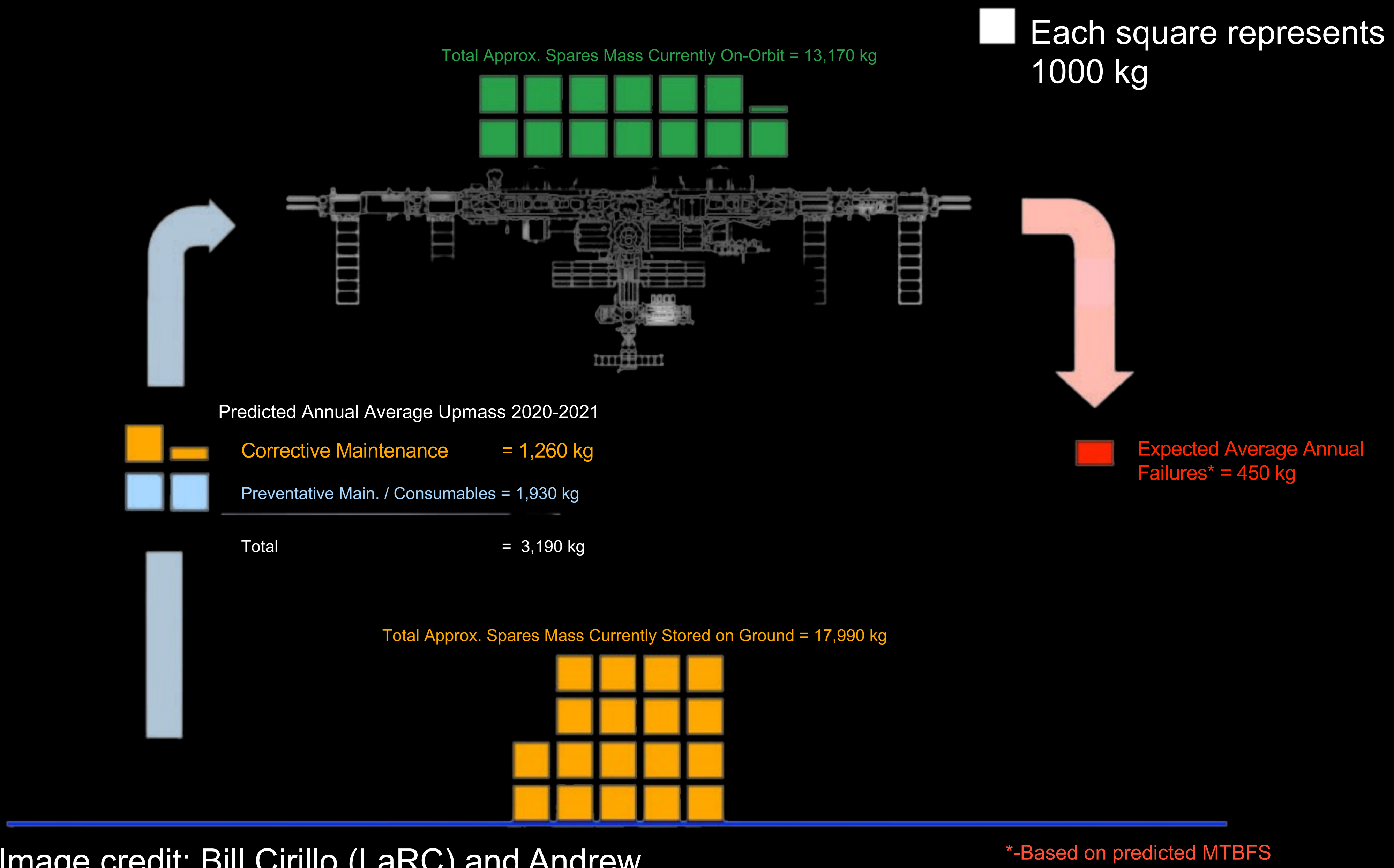


Image credit: Bill Cirillo (LaRC) and Andrew Owens (MIT)

NASA astronaut Don Pettit hiding behind ‘trash footballs’
Photo credits: NASA

International Space Station Expedition 42 Commander Barry "Butch" Wilmore shows off a ratchet wrench made with a 3-D printer on the station. The first object designed on the ***ground*** and manufactured in ***orbit***.

Image Credit: NASA

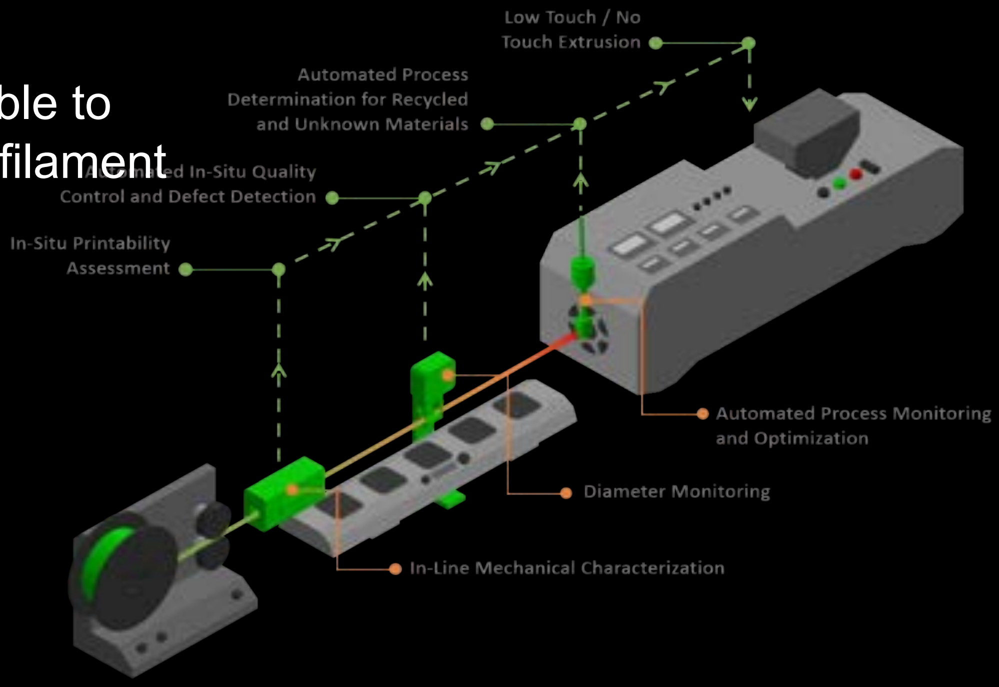
In Space Manufacturing: RnR

Goal: Develop a suite of tools that can feed data back to control an extruder leading to filament production with a consistent diameter within a tight threshold.

Why: Astronauts challenged with critical mission success will be unable to devote time to ensure high-quality filament. Additionally, inconsistent filament properties post-recycling can lead to poor filament diameter control.

In Process Monitoring

- Wound down a two-year effort with Cornerstone Research Group (CRG) to develop an in-process monitoring system for polymer filament production. (Completed August 2021)
- Demonstrated successful closed loop feedback control of the polymer extrusion process.
- Integrated diameter measurement capabilities with extrusion controller.
- Accurate and precise measurements of filament over extended periods were achieved.



In Process Monitoring Suite
Image Courtesy of Cornerstone Research Group

In Space Manufacturing: RnR

Goal: Develop and demonstrate recyclable packaging materials in a microgravity environment.

Why: Roughly 26% from overall plastic production volume is used for packaging materials which also constitutes a large proportion of ISS waste.

Reversible Thermosetting Packaging Material

To develop a foam packaging material that can be recycled aboard ISS by existing recycling system payloads.

- Identification of flame retardant chemistry and percent loading to meet outgassing and flammability requirements.
- Modification of the RVT chemistry and flame retardant percent loading to ensure printability of flame retardant copolymer.
- Identification and implementation of fillers which improve stiffness and strength of the RVT baseline filament .
- Define the useful life of the material.
- Minimize the use of consumables such as water and additives.

Recyclable Packaging Materials
Image Courtesy of Cornerstone Research Group

In Space Manufacturing: RnR

Goal: Demonstrate polymer/regolith simulant blend printing on station.

Why: As people move beyond low-Earth orbit to other celestial bodies the need for in-situ resource utilization for the fabrication of habitats will be necessary.

Redwire Regolith Print (RRP):

- Developed concept of operations, systems requirements, specimen matrix for flight and ground-based printing for technology demonstration mission, assembly of new print heads and print beds for the additive manufacturing facility (AMF), and development of linear low-density polyethylene/regolith simulant blend.
- Launched 8/10/2021

Photo Credit: Redwire

Photo Credit: Redwire

Photo Credits: NASA

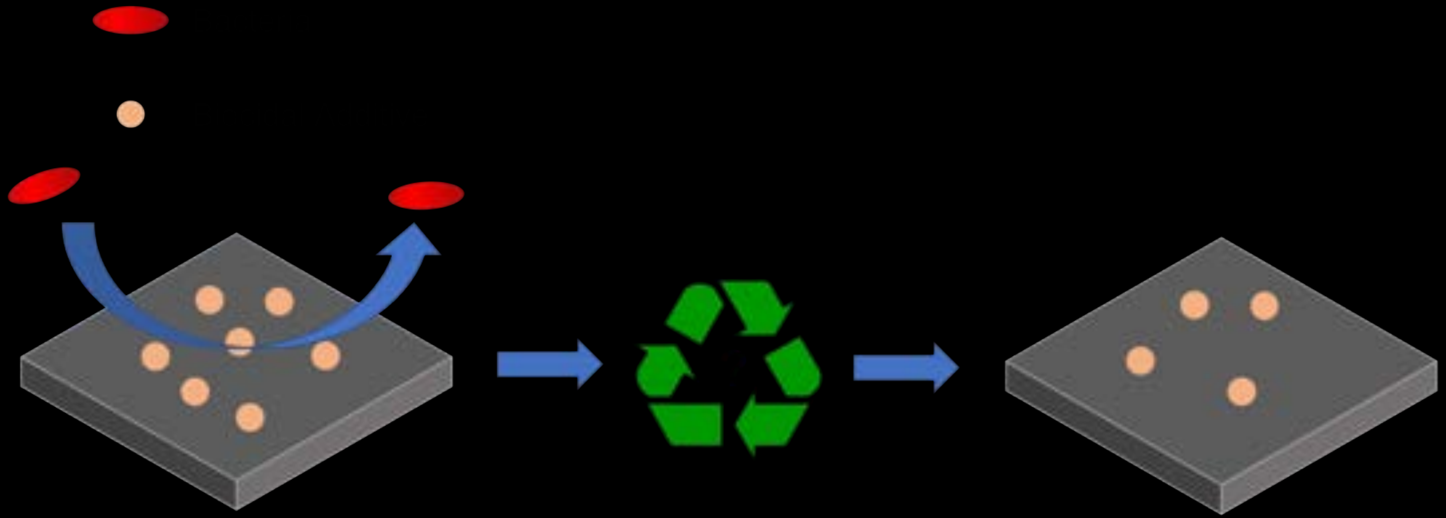
In Space Manufacturing: RnR

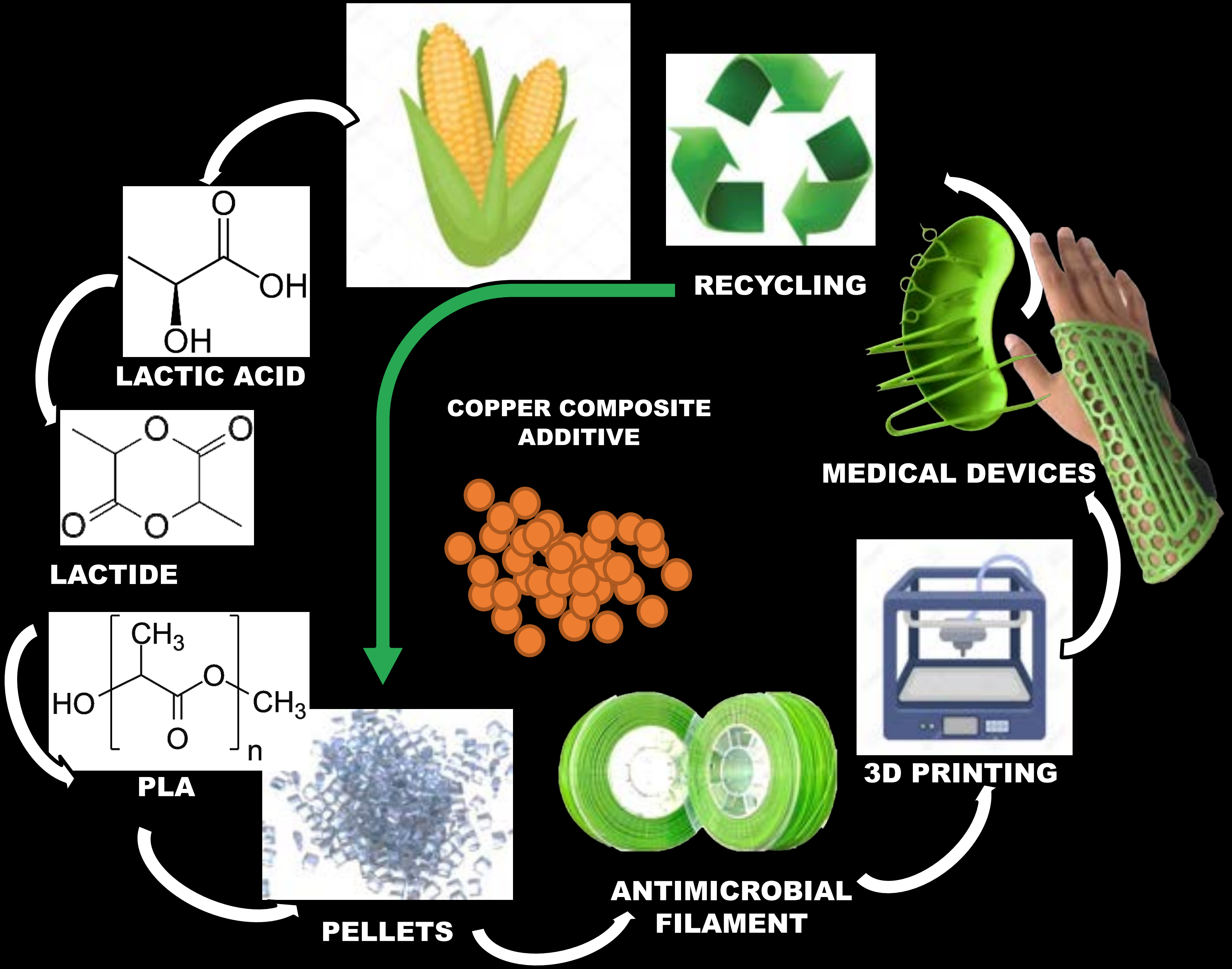
Goal: Develop and test a recyclable antimicrobial additive manufacturing filament.

Why: Crew beyond low-Earth orbit will need to produce medical devices and implants when upmassing is logistically impossible.

University of Nebraska CAN:

- A Cooperative Agreement Notification (CAN) proposal from the University of Nebraska was awarded 09/21.
  - Development and Testing of Recyclable and Antimicrobial Materials for Additive Manufacturing
  - Characterize mechanical, chemical, and biological effects of recycling on the polymer

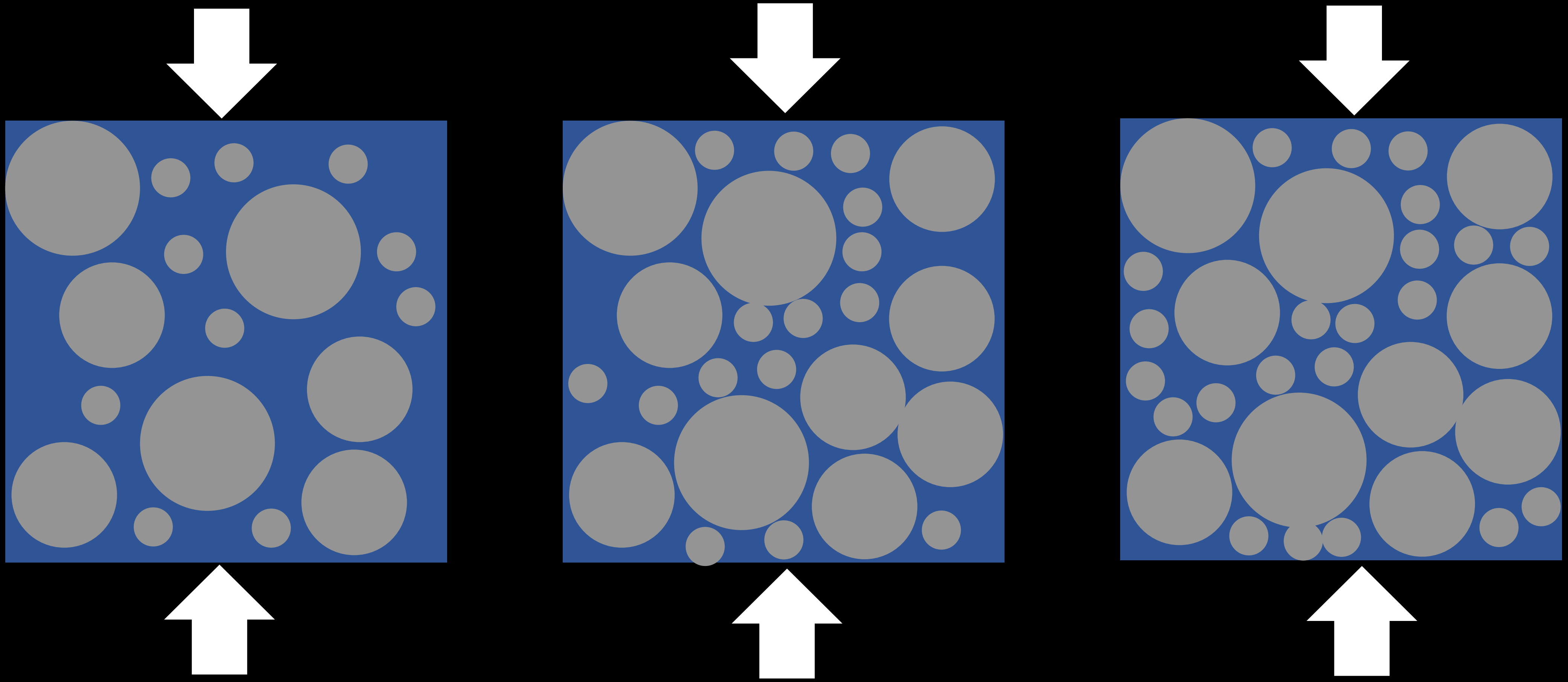




RECYCLING
O
OH
OH
LACTIC ACID
O
O
O
O
LACTIDE
COPPER COMPOSITE
ADDITIVE
MEDICAL DEVICES
CH_3
HO
O
CH_3
O
n
PLA
3D PRINTING
ANTIMICROBIAL
FILAMENT
PELLETS

Sintering Basics

Sintering is the process of compacting and forming a solid mass of material by heat or pressure without melting.



On Demand Manufacturing of Metals

Goal: The Techshot FabLab aims at maturing a <u>bound metal deposition</u> system capable of producing <u>Ti64</u> components in space providing a pioneering approach to enable sustainable and affordable exploration operations and logistics.

- Bound metal deposition technology
  - 1. A paste or filament is used to print a "green" part
  - 2. Astronaut transfers "green" part to furnace chamber
  - 3. Furnace combines a low temp thermal debind to remove binder and a high temperature sinter procedure to consolidate material
  - 4. Astronaut transfers sintered into the print module
  - 3. Finishing milling completes high precision features

  - Result: Ground-based prototype manufacturing facility printed, debound, and sintered Ti64 parts from a paste feedstock.

Parts manufactured with FabLab prototype system. Image from Techshot.

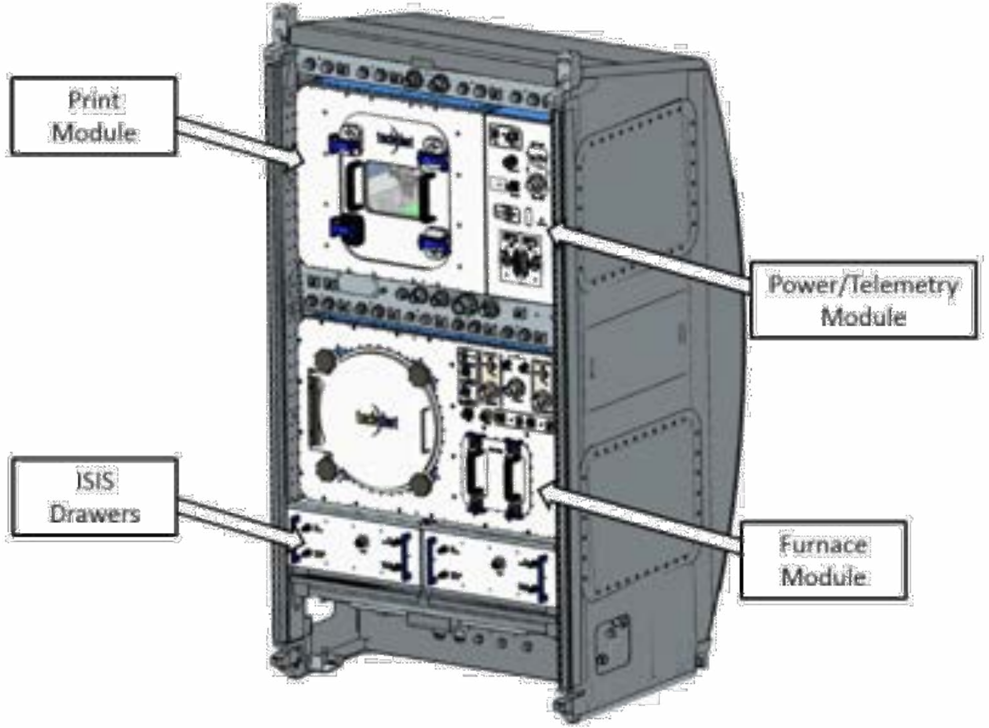
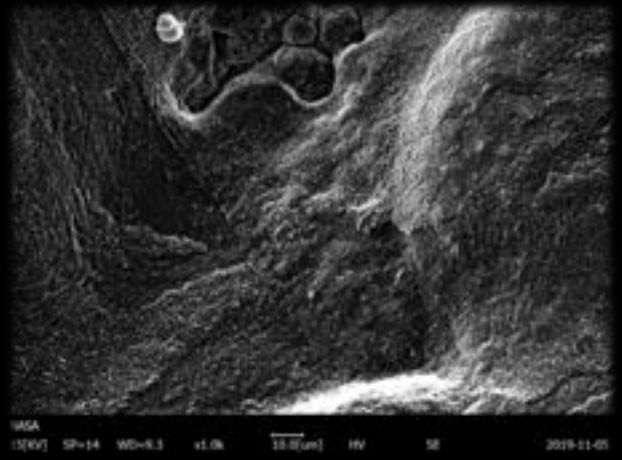


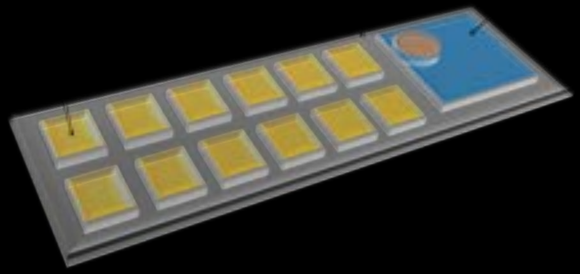
Image Credit: Techshot

On Demand Manufacturing of Electronics

- Development of post-processing processes.
  - Evaluating laser sintering, photonic sintering, and UV curing.
- Development of materials and processes for printing of electronics and sensors.
- Testing and verification of sensors, printed devices from collaboration partners.
- Materials development and printing support to our various collaboration partners.
- Leading center for the development of printed power generation and energy storage technologies.
- MSFC ODME provides the planning and project direction for other NASA ODME groups and collaboration partners.



Laser sintered Ti64



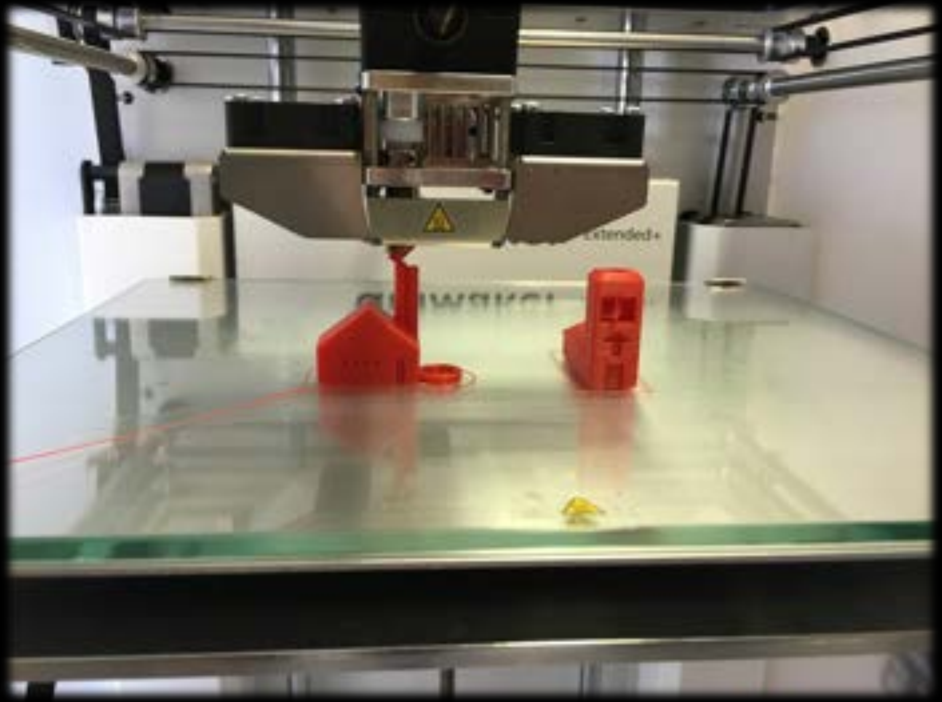
Flexible, printed thermoelectric for power generation

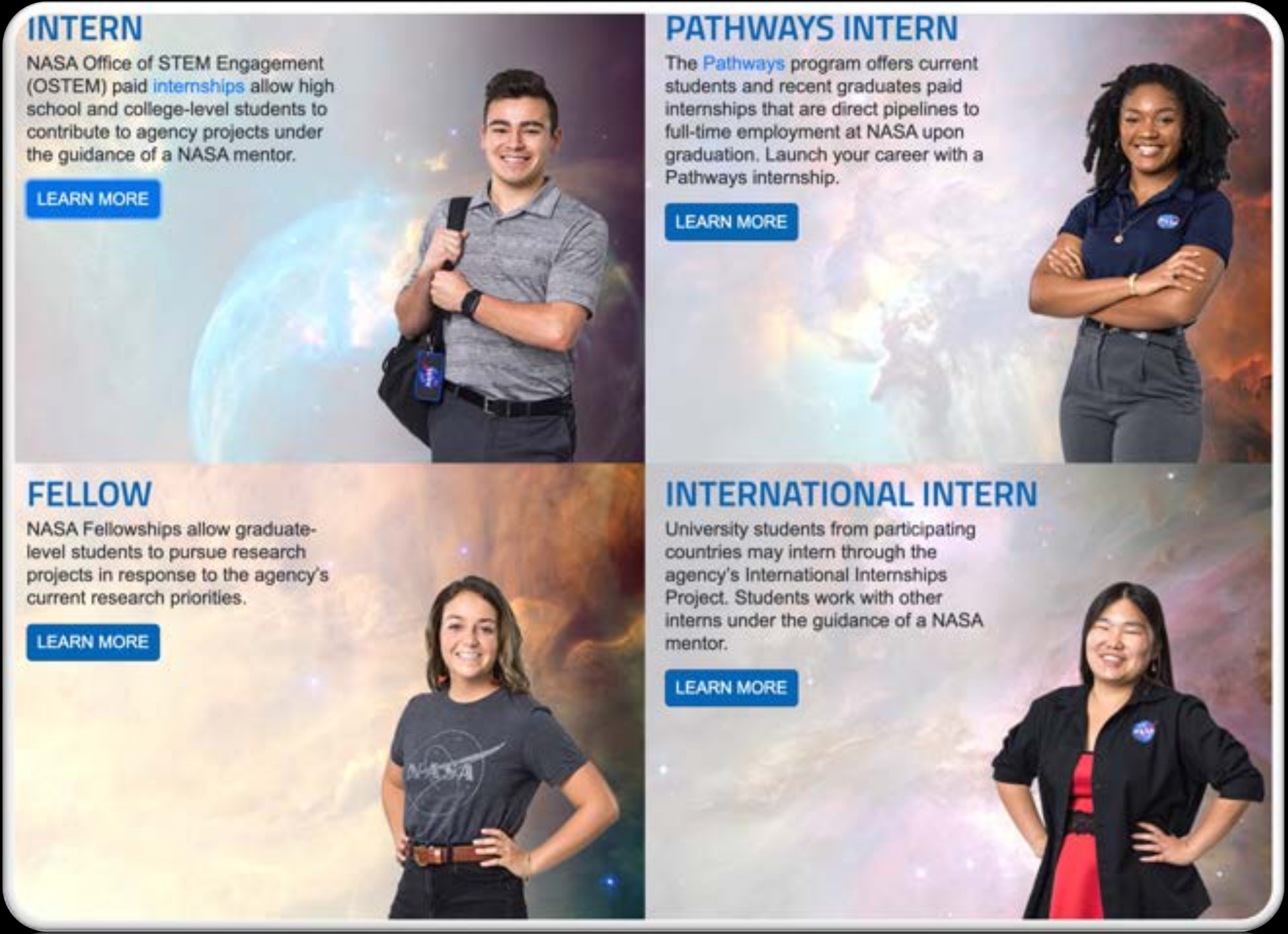
nScrypt Multimaterial 3D printer

The Technologies Developed by ISM are Just the Beginning.

Technology Gaps Still in Need of R & D:

1. Nondestructive Evaluation
2. Geometric Inspection
3. Volumetric Inspection
4. Mechanical Characterization
5. Cleaning Procedures
6. Post Processing Techniques
7. Standards for In Space Manufacturing (or implementation of existing standards)




INTERN
NASA Office of STEM Engagement (OSTEM) paid internships allow high school and college-level students to contribute to agency projects under the guidance of a NASA mentor.
LEARN MORE
PATHWAYS INTERN
The Pathways program offers current students and recent graduates paid internships that are direct pipelines to full-time employment at NASA upon graduation. Launch your career with a Pathways internship.
LEARN MORE
FELLOW
NASA Fellowships allow graduate-level students to pursue research projects in response to the agency's current research priorities.
LEARN MORE
INTERNATIONAL INTERN
University students from participating countries may intern through the agency's International Internships Project. Students work with other interns under the guidance of a NASA mentor.
LEARN MORE

Thank you.

Alexander.j.blanchard@nasa.gov